THE INSECT FAUNA OF THE PRIMARY OR PALÆOZOIC PERIOD,
AND THE BRITISH AND FOREIGN FORMATIONS OF THAT
PERIOD IN WHICH INSECT REMAINS HAVE BEEN DETECTED.

By HERBERT GOSS, F.L.S., F.G.S., &c.

(Read 7th March, 1879.)

INTRODUCTION.

In the Palæozoic rocks of the United Kingdom remains of insects appear to be extremely rare, and the few fragments which have been discovered have all been obtained from the Coal Measures. On the Continents of Europe and America fossil insects have been found more frequently in Palæozoic rocks; but with the exception of the remains of a few specimens from the Permian of Europe, and the Devonian of New Brunswick, North America, all the specimens have been discovered in the Carboniferous rocks.

From the Permian rocks only thirteen fossil insects are known, all of which have been discovered in Saxony. Two of these, from their possessing characters common to two Orders, have been placed by Dr. Goldenberg in an extinct Order, which he has called *Palæodictyoptera*.¹ Two others have been referred to the *Hemiptera*, and the remaining nine to the *Orthoptera*.

From the Carboniferous rocks about 103² species of insects have been described. Of these 5 were obtained from the United Kingdom,³ about 66 from the Continent⁴ of Europe, and 32⁵ from North America.⁶

¹ See "Fauna Saræpontana Fossilis," Heft 2, 1877.

² Inclusive of 10 species of Cockroaches, which have been described by Mr. Scudder since this paper was read in March, 1879.

³ Coalbrook Dale, Shropshire; near Sunderland; near Glasgow, &c.

⁴ Saarbrück, in the Rhenish Provinces of Prussia; Brücken Waldmohr, Rhenish Bavaria; Manebach, in Saxe Weimar; Wettin and Lobejün, in Prussian Saxony; Klein-Oritz, near Dresden; Erbniglon, Valais, Switzerland; Sars-Longchamps, Mons, and elsewhere in the Belgian Coal-fields; Commentry (Allier), France, &c.

⁵ Inclusive of the 10 species recently described by Mr. Scudder as above-mentioned.

⁶ Sydney, Cape Breton; Picton, Nova Scotia; Cannelton, Beaver County, and Pittston, Pennsylvania; Cassville, Western Virginia; Bellaire and Talmadge, Ohio; Morris, Danville and Colchester, Illinois; Frog Bayou, Arkansas, &c.

In the Coal Measures remains of the *Neuroptera* (or *Pseudo-Neuroptera*) are comparatively numerous, and in addition to some eleven species, which, (from their possessing characters common both to that Order and the *Orthoptera*,) have been placed by Dr. Goldenberg in the extinct Order¹ before-mentioned, about twenty-four species have been determined.

The *Orthoptera* of this age are represented by more than sixty² species, and this Order and the *Neuroptera*—if we include in the last-named those species which have been referred by Goldenberg to the extinct Order *Palæodictyoptera*—comprise all the insects yet discovered from the Carboniferous rocks, except five, two of which have been referred to the *Coleoptera*,³ and three to the *Hemiptera*.⁴ Had the two last-named Orders been thoroughly established, and widely distributed at this Period, their remains would doubtless have been discovered, at least as frequently as those of the *Neuroptera* and *Orthoptera*. It may be inferred, therefore, that at this period the *Neuroptera* and the *Orthoptera* were the dominant Orders, and that towards its close the *Hemiptera* and *Coleoptera* began to make their appearance.

From the Upper Devonian rocks of St. John's, New Brunswick, six species of insects have been discovered, all of which have been described by Mr. Scudder, and referred by him to the *Neuroptera*, or *Pseudo-Neuroptera*. These Devonian rocks of New Brunswick are, according to present discoveries, the oldest in the world in which any traces of insects have been detected.

Before proceeding to enumerate the fossil insects obtained from the Palæozoic rocks, I will briefly allude to those Geologists and Zoologists to whom we are chiefly indebted for their discovery, determination, or description.

Amongst the names of the authorities on the fossil *Arthropoda* from the Palæozoic rocks of the United Kingdom, the most

¹ i.e., *Palæodictyoptera*. See "Fauna Saræpontana Fossilis," p. 50 (1877).

² Inclusive of those recently described by Mr. Scudder as before mentioned.

³ *Curculioides Ansticii* and *Troxites Germari*.

⁴ *Fulgorina Ebersi*, *F. Klieweri*, and *M. Hollebeni*.

prominent is that of Dr. Henry Woodward, F.R.S.¹; and in connection with the description or determination of the fossil insects of this period, I must also mention the names of Sir Roderick Murchison, F.R.S.,² Dr. Mantell, F.R.S.,³ Dr. Buckland, F.R.S.,⁴ Mr. Robert McLachlan, F.R.S.,⁵ Mr. J. W. Kirkby,⁶ Mr. A. H. Swinton,⁷ Mr. J. W. Salter,⁸ and Mr. Curtis.

Amongst the Continental authorities on Palæozoic *Insecta* are Dr. Goldenberg,⁹ Prof. Germar,¹⁰ Prof. Oswald Heer,¹¹ Dr. Giebel,¹² Dr. Anton Dohrn,¹³ Herr Mahr,¹⁴ Dr. Jordan,

¹ See Dr. Woodward's papers in the "Geol. Magazine," Vol. viii., p. 385, 1871; Vol. ix., 1872; Vol. x. (No. 3), 1873; "Transactions of the Geol. Soc.," Glasgow, Vol. ii., pt. 3, 1867; "The Quarterly Journal of the Geol. Soc.," February, 1876, &c., &c.

² "The Silurian System" (pt. 1), pp. 104-105, 1839.

³ "The Medals of Creation," Vol. ii., p. 552, 1854.

⁴ "Bridgewater Treatise," Vol. i., pp. 409-410; and Vol. ii., pp. 75-76, 1836.

⁵ See "Compte-Rendu" of the Soc. Ent. Belge; August, 1877; and see "Nature" (No. 496), Vol. xx., pp. 5-6, May, 1879.

⁶ "Geol. Magazine," Vol. iv. (No. 39), pp. 388-390, September, 1867.

⁷ "Geol. Magazine," Vol. i. (Decade 2), p. 337, 1874.

⁸ "Quarterly Journal Geol. Soc." Vol. xix., 1863.

⁹ "Sitzungsab. math. nat. Cl. k. Akad. Wiss.," Wien, Bd. ix., pp. 38-39, Wien, 1852; "Ueber versteinerte Insektenreste im Steinkohlengebirge von Saarbrücken," Amtl. Ber. Vers. Gesellsch. deutsch. Naturf., xxix., pp. 123-26, Wiesbaden, 1853; "Die fossilen Insecten des Kohlenformation von Saarbrücken," in "Palæontographica," Vol. iv., 17-40, 1854; "Beiträge zur vorweltlichen Fauna des Steinkohlengebirges zu Saarbrücken," in the "Jahresbuch. k. Gymn. u. Vorsch. Saarbrück.," pp. 1-26, 1867; "Neues Jahrbuch für Miner.," pp. 158-168, 1869; "Neues Jahrb. für Miner.," pp. 286-289, 1870; "Fauna Saræpontana Fossilis," "Die fossilen Thiere aus der Steinkohlenformation von Saarbrücken," Heft 1, 1873, and Heft 2, 1877.

¹⁰ "Beschreibung einiger neuen fossilen Insecten," II. "In Schieferthon des Steinkohlengebirges von Wettin," see Münster's "Beiträge zur Petrefactenkunde," Heft 5, 1842; "Die Versteinerungen des Steinkohlengebirges von Wettin und Lobejün in Saalkreise," Halle 1844-1853.

¹¹ "Ueber die fossile Kakerlaken," "Vierteljahrsschrift d. Naturf. Gesellsch. in Zurich," Vol. ix., 1864; "Die Urwelt der Schweiz," Zurich, 1865; "Le Monde primitive de la Suisse" (French translation by M. Demole), Geneva and Basle, 1872; and "The Primæval World of Switzerland" (English translation by W. S. Dallas, edited by J. Heywood), London, 1876; "Die Urwelt der Schweiz" (2nd edit.), Zurich, 1879.

¹² "Fauna der Vorwelt mit steter Berücksichtigung der lebenden Insecten und Spinnen" (Insecten und Spinnen), Vol. ii., Leipsic, 1856.

¹³ "Palæontographica," Vol. xiii., p. 333, 1866; and *op. cit.*, Vol. xvi., p. 129, 1869.

¹⁴ "Neues Jahrbuch für Mineralogie," p. 282, 1870.

Herr Eugen Geinitz,¹ Dr. Hagen,² Dr. H. B. Geinitz,³ Prof. Pictet,⁴ Dr. Fric, Prof. Van Beneden,⁵ M. Coemans, M. Audouin,⁶ M. Alfred Preudhomme de Borre,⁷ and M. Charles Brongniart.⁸

For our knowledge of the fossil insects of the Palæozoic rocks of North America we are indebted chiefly to Mr. Scudder,⁹ and also to Dr. Dawson,¹⁰ Professor Dana,¹¹ Professor Leo Lesquereux,¹² Mr. Harger, Mr. C. F. Hartt, Mr. F. B. Meek, Mr. A. H. Worthen, Dr. Newberry, Mr. James Barnes, Mr. J. G. Bronson, Mr. R. D. Lacoe, Mr. R. Brown, and Mr. J. F. Mansfield.

I will now proceed to enumerate the fossil insects which have been described from the Primary rocks. After having done this, I shall briefly review the facts which have been brought under notice in this and the two preceding papers, and shall endeavour to suggest a few deductions which may be drawn therefrom.

¹ "Neues Jahrbuch für Min.," pp. 691-704, 1873; "Neues Jahrbuch für Min.," pp. 1-14, 1875.

² "Linnaea Entomologica," Zeitschrift von dem Entomologischen Vereine in Stettin," Band 10, p. 302, 1855.

³ "Sitzungsb. naturw. Gesellsch. Isis," pp. 7-13, Dresden, 1879.

⁴ "Traité élémentaire de Paléontologie," Geneva, 1846, and Paris, 1854.

⁵ "Bull. Acad. Royale de Belgique," 2^{me} Serie, T. xxiii., No. 4, 1867.

⁶ "Ann. Soc. Ent. France," Vol. ii., Bull., pp. 7-8, 1833.

⁷ "Notes sur des empreintes d'insectes fossiles," "Ann. Soc. Ent. Belgique," T. xviii., 1875.

⁸ "Ann. Soc. Ent. France," v^{me} Serie, 1876; "Comptes-Rendu Soc. Ent. Belge," pp. 9-12, January, 1878; and "Ann. des Sciences Naturelles," 6^{me} Serie, Tome 7 Art. No. 4, 1879.

⁹ See Dawson's "Acadian Geology," 2nd edit., p. 388, London, 1868; "The Geological Survey of Illinois" (Worthen), Vol. iii., pp. 566-572, 1868; "Canadian Naturalist" (N.S.), Vol. vii., pp. 271-272, Montreal, 1874; "Proc. Amer. Assoc. adv. Science," Vol. xxiv., pp. 110-111, Salem, 1876; "Canad. Nat." (N.S.), Vol. viii., pp. 88-90, Montreal, 1876; "Geol. Mag." (N.S.), Vol. iii., pp. 519-520, London, 1876; "Proc. Bost. Soc. Nat. Hist.," Vol. xix., pp. 238-239, Boston, 1878; "The Early Types of Insects," Bost. Soc. Nat. Hist., Vol. iii. Part 1, No. 2, Boston, March, 1879; "Palæozoic Cockroaches," Memoirs of the Bost. Soc. Nat. Hist., Vol. iii., pt. 1, No. 3, pp. 23-134, Boston, November, 1879.

¹⁰ "Quart. Journal Geol. Soc., Lond.," Vol. xvi., p. 268; "Geol. Mag.," Vol. iv., No. 9, 1867; and "Acadian Geology," 1868.

¹¹ "Sill. Journ." (2), Vol. xxxvii., pp. 34-35, 1864.

¹² Owen's 2nd "Report Geol. Arkansas," pp. 295-399, 1860.

GREAT BRITAIN.

CARBONIFEROUS.

Of the five fossil insects obtained from the British Coal-measures, four have been referred to the *Orthoptera*, and one to the *Coleoptera*. The representative of the last-named order is the oldest British fossil insect known. It was discovered in the Ironstone of Coalbrook Dale, Shropshire, and was described by Dr. Buckland¹ as *Curculioides Ansticii*.²

The first discovered species of *Orthoptera* from the British Carboniferous rocks was also obtained from the Ironstone of Coalbrook Dale. Sir Roderick Murchison³ observes of this fossil:—“It was supposed to be a plant, and was sent to Adolphe Brongniart, who immediately perceived that the transverse nervures were unlike anything in the vegetable kingdom, and on being referred to M. Audouin, it was pronounced to be the wing of a *Neuropterous* insect, resembling the living *Corydalis* of Carolina and Pennsylvania.” It was subsequently described by Dr. Mantell⁴ as belonging to the genus *Corydalis* of the *Neuroptera*, and was named by him *Corydalis Brongniarti*. Mr. Swinton has since referred this insect to the genus *Gryllacris* of the *Orthoptera*.⁵

In addition to these fossils, three fragments of *Orthoptera* were discovered, some years ago, in the Durham Coal-fields.⁶ One of the fragments is described by Mr. Kirkby as being a very fine distinct example of the anterior portion of the fore wing of an insect, in form and neuration agreeing with the genus *Blatta*, but

¹ “Bridgewater Treatise,” Vol. ii., *antea cit.*, p. 76; see also the “Geol. Trans.” (2nd series), Vol. v., pt. 3, p. 446; and “The Silurian System,” *antea cit.*, pp. 104–105.

² Dr. Buckland describes two insects from Coalbrook Dale as *Curculionidæ*, i.e., *C. Ansticii* (above-mentioned) and *C. Prestvicii*; but Dr. H. Woodward, has decided that the last-named fossil should have been referred to the *Arachnida* and not to the *Insecta*. See “Geol. Mag.,” Vol. viii., p. 385, September, 1871.

³ “The Silurian System” (pt. I), *antea cit.*, pp. 104–105.

⁴ “Medals of Creation,” Vol. ii., p. 552, 1854.

⁵ See a paper by Mr. A. H. Swinton in “Geol. Mag.,” p. 337, pl. xiv., August, 1874.

⁶ The locality was the North bank of the Wear, opposite to Claxheux, about two miles west of Sunderland. See Mr. Kirkby’s paper in the “Geol. Mag.,” Vol. iv., p. 388, 1867.

approaching the *Mantidæ*.¹ The third² specimen is believed from its shape and neurulation, to be the abortive anterior wing of some species belonging to the *Phasmidæ*, but it is impossible to pronounce with any certainty as to its probable affinities.

The most recently discovered fossil insect from British strata of this period was found in a clay-ironstone nodule obtained from the Scottish Coal-fields. It has been referred³ by Dr. Henry Woodward to the *Mantidæ*, and has been named by him *Lithomantis carbonarius*.

CONTINENT OF EUROPE.

PERMIAN.

The Permian rocks are extensively developed in Russia and Germany, and they also occur in some parts of Great Britain and North America; but from their comparatively limited geographical and superficial range, the number of fossils obtained from them is proportionately small, and of the *Insecta* only about thirteen species have been discovered, all of which were found in that part of Germany⁴ which has been styled by Lyell⁵ "the classic ground" of this formation on the Continent.

One of the first discovered and most interesting of these insects, was obtained from an Ironstone pit, belonging to Herr Böcking, at Schwarzenbach in the district of Birkenfeld, and was described in 1866 by Dr. Anton Dohrn,⁶ who named it *Eugereon Böckingi*.⁷ Dr. Dohrn states that Herr Tischbein and Dr. Hagen

¹ Dr. Goldenberg has included this insect in his list of fossil *Blattidæ*, under the name of *Blattidium mantidioides*. (See "Fauna Sar. Fossilis," pt. 2, p. 20, 1877).

² The second specimen appears to be a part of the same insect as No. 1.

³ "Quart. Journal Geol. Soc.," February, 1876, p. 60. In deciding as to the family to which this fossil belonged, Dr. Woodward states that he had the advantage of the opinions of Mr. Mc Lachlan, Prof. Westwood, and Mr. C. O. Waterhouse.

⁴ Schwarzenbach, near Birkenfeld Cassel, and Weissig, near Pillnitz, in Saxony.

⁵ "Elements of Geology," 6 edit., p. 460.

⁶ "Palæontographica," Vol. xiii., p. 333, 1866.

⁷ For a description of this fossil, see "Palæontographica," last cit.; and also Vol. xvi., p. 129, 1869; the "Stettiner Ent. Zeitung," xxviii., 1867; and Goldenberg's "Fauna," pt. 2, ante cit., pp. 11-14, 1877.

both regarded this insect as an *Hemipteron*, and he adds that he was originally of the same opinion himself, but that after a further examination of this remarkable fossil, he decided that it could not be referred to any existing Order, as it combined characters both of the *Neuroptera*¹ and *Hemiptera*.

Dr. Dohrn does not, of course, regard *Eugereon* as a type of the common ancestor or progenitor of the *Neuroptera* and *Hemiptera*, as both these Orders were already in existence; but he is of opinion, that at a very remote period a form existed, completely intermediate between these two Orders, from which they were differentiated, and from which *Eugereon* was also descended.

As this insect could not be referred to any existing Order, it was placed by its describer in a new Order, which he created for it, and which he named *Dictyoptera*; it has recently been included by Dr. Goldenberg² in his Order *Palæodictyoptera*.

Another fossil, scarcely less interesting than *Eugereon*, discovered by Herr Karl Rückert in the neighbourhood of Stockheim, in Bavaria, was described in 1865 by Dr. H. B. Geinitz,³ who named it *Ephemerites Rückerti*. From its union of characters of the genera *Ephemer* and *Libellula*, Dr. Goldenberg has recently placed this fossil in his Order *Palæodictyoptera*.

A fragment of a wing, obtained from Weissig, near Pillnitz, in Saxony, has been referred by Herr Eugen Geinitz⁴ to a species of *Hemiptera*—*Fulgorina Klieveri*—a specimen of which has been also obtained⁵ from the European Coal Measures; but Dr. Goldenberg has recently informed⁶ me that he is not aware of any specimen of the last-named species (*F. Klieveri*) having been discovered in Permian strata; but that two other species belonging to the genus *Fulgorina*, viz., *F. Ebersi* and *F. lebachensis*, have been obtained from the Permian.

The nine other insects discovered in strata of this age all belong

¹ All the synthetic types hereinafter alluded to exhibit a union of the characters of *Neuroptera* and *Orthoptera*, or *Neuroptera* and *Pseudo-Neuroptera*.

² "Fauna Sar. Foss.," pt. 2 (1877), *antea cit.*, p. 50.

³ "Neues Jahrb. für Min.," pp. 385-388, 1865.

⁴ See "Neues Jahrb. für Min.," pp. 6 and 12, and plate 1, fig. 3, p. 112, 1875.

⁵ Described by Dr. Goldenberg in "Neues Jahrb. für Min.," p. 166, 1869.

⁶ In a letter dated 12th January, 1879.

to the extinct genus *Blattina*¹ of the family *Blattidæ* of the *Orthoptera*, and the majority of them were obtained from Weissig. Of these *Blattidæ*, five species—*Blattina Weissigensis*,² *B. porrecta*,³ *B. Rückerti*, *B. lebachensis*, and *B. gracilis*—have only been discovered in Permian strata, but specimens of the remaining four, viz., *B. didyma* (*sopita*), *B. anthracophila* (*flabellata*), *B. carbonaria*, and *B. Mahri* (*elongata*) have been also obtained from the European Coal Measures.

The specimen of *Blattina didyma*⁴ (*sopita*) from the Permian appears, for an insect of such vast antiquity, to be in an unusually perfect state of preservation, the body, wings, and legs being almost entire; but the other *Blattidæ* are represented only by single wings, or parts of wings.

CARBONIFEROUS.

The principal localities on the Continent of Europe in which fossil insects have been discovered in the Carboniferous rocks, are Saarbrück, in the Rhenish provinces of Prussia; Brücken, Waldmohr, Rhenish Bavaria; Manebach, in Saxe Weimar; Wettin and Löbejün, in Prussian Saxony; Klein-Opitz, near Dresden; Erbignon Valais, Switzerland; Sars-Longchamps, and Mons. Belgium; and Commentry (Allier), France.

Of *Neuropteroid* insects about sixteen species have been obtained from the neighbourhood of Saarbrück, nine⁵ of which have been referred by Dr. Goldenberg⁶ to an extinct genus—*Dictyoneura*—and have recently been placed by him in the extinct Order *Palæodictyoptera*. The remaining seven species are representatives of the family *Termitidæ*, viz., *Termes Heeri*, *T. affinis*, *T. Hageni*, *T. Buchi*, *T. laxa*, *Termitidium amissum*, and *rugosum*.

About fourteen years ago M. Coemans discovered at Sars-Longchamps, in the Belgian Coal-fields, the wing of an insect in a

¹ Mr. Scudder has recently distributed these Permian *Blattidæ* amongst his new genera—*Etioblattina*, *Anthracoblattina*, *Hermatoblattina*, and *Petrablattina*.

² Described by Herr Eugen Geinitz, in "Neues Jahrb. für Min.," pp. 692-694, 1873.

³ Eug. Geinitz in "N. Jahrb. für Min.," p. 6, 1875.

⁴ See "N. Jahrb. für Min.," 1875, *antea cit.*, plate 1, fig. 1, p. 112.

⁵ *Dictyoneura libelluloides*, *anthracophila*, *formosa*, *Decheni*, *elegans*, *elongata*, *Schmitzii*, *obsoleta*, and *Humboldtiana*.

⁶ "Fauna Saræpontana Fossilis," *antea cit.*, 1873 and 1877. See also "Palæontographica," Vol. iv., 1854.

tolerably perfect state of preservation, which was referred by him and Prof. Van Beneden to an extinct genus of *Neuroptera*. This fossil was subsequently described¹ by them as *Omalia macroptera*, and it has since been included by Dr. Goldenberg² in his Order *Palæodictyoptera*.

In 1874 three specimens, or rather fragments, of insects were discovered by M. Persinaire and M. Crepin, in the Mons basin of the Belgium Coal-fields, and were subsequently described by M. Alfred Preudhomme de Borre.³ One of the fragments was supposed to be part of the wing of a species of *Termes*, but it was in far too imperfect a state to admit of its determination.

The most perfectly preserved wing of the three⁴ was originally described by M. de Borre as belonging to the *Orthoptera*, and was named by him *Pachytylopsis Borinensis*⁵; but after Dr. Breyer had examined it, and expressed an opinion that it belonged to the *Lepidoptera*, its name was changed to *Breyeria Borinensis*. This fossil was subsequently submitted to Mr. McLachlan,⁶ in Brussels, in August, 1877, and he decided, after a careful examination of the wing, in which he detected abundant traces of transversal reticulation, that it could not have belonged to the *Lepidoptera*,⁷ and that it was the wing of a *Neuropterous* insect of the family *Ephemeridæ*.

The fossil *Orthoptera* from the European Coal Measures belong, with few exceptions, to the *Blattidæ*, of which family about thirty-six species have been described by Germar, Goldenberg, Giebel, Heer, H. B. Geinitz, E. Geinitz, Dohrn, and Mahr, viz., *Blattina primæva*,⁸ *labachensis*, *insignis*, *winteriana*, *intermedia*, *scaberata*,

¹ "Bull. Acad. Royale Belgique," 2nd Series, Tome xxiii, pp. 384-401, 1867.

² "Fauna Sar. Fos.," Heft 2, *antea cit.*, 1877.

³ "Notes sur des empreintes d'insectes fossiles." "Ann. Soc. Ent. Belgique," Tome xviii., 1875.

⁴ For the name of the second specimen belonging to the family *Acrididæ* of the *Orthoptera*, see next page.

⁵ "Bull. Acad. Royale Belgique," *antea cit.*

⁶ "Compte-Rendu Soc. Ent. Belgique," August, 1877, *antea cit.*; and "Nature" (No. 496), Vol. xx., pp. 5-6, May, 1879.

⁷ Mr. Alfred Russel Wallace believes the wing to be *Lepidopterous*. See "Nature" (No. 495), Vol. xix., p. 582, April, 1879.

⁸ Since this paper was read in March, 1879, Mr. Scudder has re-described all the known species of fossil cockroaches from Europe and America in a very long and elaborate paper, published in the "Memoirs of the Boston Society of Natural History" (Vol. iii., pt. 1, No. 3, *antea cit.*). With the exceptions of *Tischbeini*, *latinervis*, and *granosus*, the two first of which are still referred to the genus *Blattina*, and the last named to the genus *Poly-*

wemmetsweileriensis, *Tischbeini*, and *Polyzosterites granosus* from the neighbourhood of Saarbrück; *B. Remigii* and *weissiana*, from Cusel and Brücken respectively; *B. didyma*, *Manebachensis*, *Goldenbergi*, *latinervis*, *clathrata*, *Mahri*, and *Fritschii*, from Manebach; *B. euglyptica*, *affinis*, *flabellata*, *anthracophila*, *Dohrmii*, *anaglyptica*, *carbonaria*, *russoma*, *leptophlebica*, *parvula*, *spectabilis*, *Geinitzi*, *Münsteri*, *producta*, *Germari*, and *reticulata*, from Wettin and Löbejün; *B. Dresdensis*, from Klein-Opitz, near Dresden; and *B. Helvetica*, from Erbignon Valais, which according to Professor Heer¹ is the most ancient Swiss fossil animal known.

The other *Orthoptera* from the European Coal Measures include *Gryllacris lithanthraca*² and *Acridites formosus*³ from the neighbourhood of Saarbrück; *Pachytylopsis Persenairei*⁴ from the Belgian Coal-fields; and one species of *Phasmidæ* from the Upper Coal Measures of Commentry, which has been described by M. Charles Brongniart⁵ and named by him *Protophasma Dumasii*. M. Brongniart observes of this species that it approaches *Phasma variegatum* in its neururation.

The only representatives of the *Hemiptera* from the Carboniferous rocks are *Fulgorina (Fulgora) Ebersi*⁶ and *Klieveri*⁷ from Saarbrück, and *Macrophlebium Hollebeni*⁸ from Mannebach.

The *Coleoptera* are represented by one specimen—*Troxites Germari*⁹—from Saarbrück, and by traces of borings in petrified wood from the Carboniferous Limestone of Autun, which are believed by M. Charles Brongniart¹⁰ to have been made by a species

zosterites, all the species have been distributed by Mr. Scudder amongst new genera created by him, viz., *Etoblattina*, *Gerablattina*, *Anthracoblattina*, *Progonablattina*, *Petrablattina*, *Oryctoblattina*, and *Hermatoblattina*.

¹ "Viertelj. Naturf. Gesellsch. Zürich," ix., 287, 291-293, 1864; "Die Urwelt der Schweiz," 1st edit. (529, Note), 1865; and 2nd edit. p. 24, Zürich, 1879.

² "Palæontographica," Vol. iv., 1854; "Fauna Saræpontana Fossilis," Heft 1, p. 20, 1873.

³ *Op.* last cited, pp. 18-19.

⁴ "Ann. Soc. Ent. Belgique," Tome xviii., 1875 (*antea cit.*).

⁵ "Compte-Rendu. Soc. Ent. Belgique," Serie 11, No. 47 (pp. 9-12), January, 1878; and "Annales des Sciences Naturelles," 6me Serie, Tome 7, 2.4, Article No. 4, 1878.

⁶ "Palæontographica," Vol. xvi., 1869; "Fauna Sar. Foss.," Heft 2, pp. 28-30, 1877.

⁷ "Neues Jahrbuch für Min.," 1869; "Fauna Sar. Foss.," Heft 2, p. 31, 1877.

⁸ "Neues Jahrb. für Min.," pp. 158-168, 1869.

⁹ "Palæontographica," Vol. iv., 1854; and "Fauna Sar. Foss.," Heft 1, p. 7, 1873.

¹⁰ "Annales Soc. Ent. France," Vme Series, 1876.

of *Hylesinus*. Dr. Geinitz has also referred similar borings in fossil wood, in the Coal Measures of Saxony, to a beetle which has been named by Dr. Fric *Xyloryctes planus*.

AMERICA.

CARBONIFEROUS.

The fossil insects obtained from the American Carboniferous rocks all belong to the *Neuroptera* and *Orthoptera*.

The *Neuroptera* are represented by thirteen species, viz., *Miamia Bronsoni*¹ and *Danæ*,² *Crestotes lapidea*,³ *Hemeristia occidentalis*,⁴ *Megathentomum pustulatum*,⁵ *Euephemerites simplex*,⁶ *gigas*,⁸ *affinis*,⁶ and *primordialis*,⁷ *Libellula* (?) *carbonaria*,⁸ *Haplophlebium Barnesii*,⁹ *Paolia vetusta*,¹⁰ and *Termes contusus*¹¹.

From the neururation of the wings of the species respectively belonging to the genera *Miamia* and *Hemeristia*, Mr. Scudder is of opinion that each represents a new family of *Neuroptera*, containing peculiarities, both of *Neuroptera* proper and *Pseudo-Neuroptera*. The species belonging to the genus *Termes* (*T. contusus*) is especially interesting as being, I believe, the only fossil specimen of a white ant discovered in America. Amongst the remains referred by Scudder to the genus *Euephemerites* is "the well¹² defined wing of an insect of marked simplicity" (*E. primordialis*). Mr. Scudder observes that in this ancient wing scarcely the slightest differentiation has begun. In this respect, therefore, this wing differs from all others yet discovered; for even in

¹ "Silliman's Journal" (2), Vol. xxxvii., p. 34.

² "Geol. Illinois," Vol. iii., p. 566.

³ *Op. last cited*, Vol. iii., p. 567.

⁴ "Sill. Jourl." (2), Vol. xxxvii., p. 34.

⁵ "Geol. Ill.," Vol. iii., p. 570.

⁶ *Op. last cited*, pp. 472 and 571.

⁷ "Proc. Bost. Soc. Nat. Hist.," Vol. xix., p. 37, 1878.

⁸ "Proc. Amer. Assoc. Adv. of Science," Vol. xxiv., p. 110; and see "Geol. Mag." (No. 149), Vol. iii., N.S., p. 519, 1876.

⁹ Dawson's "Acadian Geology," p. 387, 1868; and "Geol. Magazine" (No. 39), Vol. iv., p. 386, 1867.

¹⁰ "Silliman's Jour." (3).

¹¹ "Proc. Bost. Soc. Nat. Hist.," Vol. xix., p. 54, 1878.

¹² *Proc. last cited*, p. 37.

those obtained from the Devonian rocks, the differentiation of the wings is scarcely less perfect than in living insects.

The fossil referred to the genus *Libellula* is supposed to be the abdomen of a larval Dragon-fly ; but it appears to me to be so imperfect and fragmentary, that it is impossible to say to what insect it belonged. It is extremely improbable that this fossil should have belonged to the *Odonata*, which, although abundantly represented in the Jurassic rocks of Solenhofen, and also—though less commonly—in the English Lias, are unknown in rocks of greater antiquity.

The fossil named *Haplophlebium Barnesii*¹ appears to have belonged to the *Ephemeridæ*, and consists of a long narrow² wing, about three and a-half inches in length, so that the insect, when expanded, must have measured over seven inches, and have been much larger than any living species of that family. Mr. Scudder says of it—"The extreme simplicity of the neurulation probably places this insect among the *Ephemerina*, although the form of the wing and the reticulation recall the *Odonata* ; other features of the wing resemble the *Odonata*, and it is not impossible that *Haplophlebium* forms a synthetic type, combining essential characters of *Odonata*³ and *Ephemerina*."

In alluding to the family (*Ephemeridæ*) to which this gigantic species has been referred, Dr. Dawson observes—"When we consider that the larvæ of such creatures inhabit the water, and delight in muddy bottoms, rich in vegetable matter, we can easily understand that the swamps and creeks of Carboniferous Acadia must have been especially favourable to such creatures, and we can imagine the larvæ swarming on the deep black mud of the ponds in these swamps, and furnishing a great part of the food of the fishes inhabiting them, while the perfect insects emerging from the waters, to enjoy their brief space of ærial life, would flit in millions over the quiet pools and through the dense thickets of the Coal swamps."⁴

¹ Dr. Goldenberg has placed this fossil in the extinct order *Palæodictyoptera* before referred to. "Fauna Sar. Foss.," Heft 2, 1877.

² See plate xvii., fig. 1, 391, "Geol. Mag.," September, 1867. See also "A Manual of Palæontology," by Prof. Alleyne Nicholson, M.D., p. 186, fig. 129; and Dawson's "Acadian Geology," p. 387, 1868.

³ Dr. Dawson is of the same opinion. See "Geol. Mag." (No. 39), Vol. iv., p. 386, 1867.

⁴ "Geol. Mag." (No. 39), Vol. iv., p. 386 (*antea cit.*).

With the exception of a cricket—*Archegogryllus priscus*¹—and a supposed species of *Mantis*,² all the *Orthoptera* from the Carboniferous rocks of America (amounting to nineteen in number) belong to the *Blattidæ*³ (Cockroaches), viz., *Blattina venusta*,⁴ *Heeri*,⁵ *Bretonense*,⁶ *sepulta*,⁷ and *fascigera*,⁸ *Mylacris anthracophilum*,⁹ *Pennsylvanicum*,¹⁰ and *Mansfieldi*,¹¹ *Archymylacris acadicum*,¹² and *parallelum*,¹³ *Necymylacris heros*,¹³ and *lacoanum*,¹³ *Lithomylacris angustum*,¹³ *pittstonianum*,¹³ and *simplex*, *Gerablattina balteata*,¹³ and *Etblattina Lesquereuxii*.¹³

These seventeen species of Cockroaches have been arranged by Mr. Scudder¹⁴ in two groups—*Mylacridæ* and *Blattinariæ*—in the first of which he has placed *Bretonense*, *Heeri*, *Pennsylvanicum*, *Mansfieldi*, *heros*, *angustum*, *Pittstonianum*, *lacoanum*, *simplex*, and *anthracophilum*; and in the second *sepulta*, *acadicum*, *parallelum*, *Lesquereuxii*, *fascigera*, *balteata*, and *venusta*. With the exceptions of *venusta*, *Heros*, *parallelum*, *fascigera* and *sepulta*, which were obtained from the Millstone Grit,¹⁵ all the other specimens were discovered in the Coal Measures.

¹ "Proc. Bost. Soc. Nat. Hist.," Vol. xi., p. 402.

² "Geol. Ill.," Vol. iii., p. 567.

³ Mr. Scudder has recently divided this family into two groups—*Mylacridæ* and *Blattinariæ*. See "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 3, November, 1879, *antea cit.*

⁴ "Owen's 2nd Rep. Geol. Arkansas," p. 314.

⁵ "Can. Nat." (N.S.), Vol. vii., p. 272.

⁶ *Op.* last cited, p. 271.

⁷ "Proc. Amer. Assoc. Adv. Science," Vol. xxiv., p. 111.

⁸ "Proc. Bost. Soc. Nat. Hist.," xix., pp. 238-239.

⁹ "Geol. Ill.," Vol. iii., p. 568.

¹⁰ "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 3, 1879.

¹¹ *Op.* last cited.

¹² "Acadian Geology," p. 388, 1868; and "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 3, *antea cit.*

¹³ *Op.* last cited. With the exception of *B. venusta*, *Heeri*, *Bretonense*, *sepulta*, and *fascigera*, *Mylacris anthracophilum*, and *Archimylacris acadicum*, all these *Blattidæ* have been described by Mr. Scudder in the "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 3 *antea cit.* since the date at which this paper was read.

¹⁴ "Proc. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 3 *antéa cit.*

¹⁵ *Op.* last cited, p. 36.

NOTE.—All the species described or re-described in the work last mentioned have been referred to genera which, with the exceptions of *Mylacris* and *Archymylacris*, were previously uncreated.

DEVONIAN.

The six oldest known fossil insects were obtained by Mr. C. F. Hartt, from the Devonian rocks of New Brunswick. The locality in which they were found has been named by their discoverer "Fern Ledges," and is situated about a mile west of the town of Carleton, near St. John's. The rocks at this place are described as forming a series of ledges exposed on the sea shore between high and low water mark, and consisting of sandstone and fossiliferous shales rich in plant remains. Some doubt as to the age of these rocks has been expressed by Dr. Geinitz,¹ who considered them as probably belonging to the Carboniferous formation from the fact that one of the insects obtained from them was associated with a fern characteristic of that formation; but Dr. Dawson² believes that from their containing beds richly stored with Devonian plants, and underlying unconformably the oldest portion of the Carboniferous series, they belong most unquestionably to the Devonian formation, and his opinion has been accepted by all the leading geologists in Europe and America.

As these Devonian insects are the most ancient representatives of their Class yet discovered, they are especially interesting, and are probably worthy of a more detailed notice than has been bestowed in these papers on the majority of those obtained from more modern rocks. They have all been described³ by Mr. Scudder, and respectively named by him *Xenoneura antiquorum*, *Gerephemera simplex*, *Platephemera antiqua*, *Lithentomum Harttii*, *Dyscritus vetustus*, and *Homothetus fossilis*.

Xenoneura antiquorum and *Gerephemera simplex* were obtained from a lower portion of the shales than any of the others, and are therefore, presumably, the oldest of the six. The first-named fossil, *X. antiquorum*, appears to be the basal portion of a small wing, which was probably about two inches in expanse. From the peculiar nature of its neuration Mr. Scudder is of opinion that it represents an extinct family of *Neuroptera*, and probably belonged

¹ "Sitzungsb. der Naturf. Gesellsch." Isis, Dresden, 1866.

² "Geol. Mag.," Vol. iv., p. 386, 1867.

³ See Bailey's "Observations on the Geology of Southern New Brunswick," Appendix A., pp. 131-141, 1865; "Geol. Mag.," Vol. v., pp. 175-176; Vol. iv., pp. 387-388; "Acadian Geol.," *antea cit.*, p. 525; and Dana's "Manual," *antea cit.*, p. 273-274.

to a group constituting a synthetic type between the *Orthoptera* and *Neuroptera*. He observes that the most striking peculiarity in this specimen is the development of apparently independent veinlets, forming portions of concentric rings, at the base of the wings, which he compared to the stridulating organ of some male saltatorial *Orthopteron*. Dr. Dawson,¹ in alluding to this peculiarity in this specimen, remarks that "nothing is more curious than the "apparent existence of a stridulating or musical apparatus, like that "of the cricket, in an insect otherwise allied to the *Neuroptera*. "This structure also," continues Dr. Dawson, "if rightly interpreted by Mr. Scudder, introduces us to the sounds of the Devonian "woods, bringing before our imagination the trill and hum of insect "life that enlivened the solitudes of these strange old forests."²

The second specimen, *G. simplex*, consists of a fragment of the tip of a large broad wing, which appears to have belonged to a member of the *Ephemerina*.

The third specimen, *P. antiqua*, is believed to be a portion of the upper wing of a gigantic species of the *Ephemerina*, which must have measured five inches in expanse of wings, and from its combination of peculiarities³ of structure now only found in different groups must also be regarded as a "synthetic type."

The fourth specimen, *L. Hartii*, is supposed to be a portion of the lower wing of a *Neuropterous* insect, measuring about three and a-half inches in expanse of wings, and allied to the *Sialina*, but not belonging to any family represented among existing forms.

The fifth specimen, *D. vetustus*, is represented by so small a fragment of a wing that Mr. Scudder considers it impossible to determine the approximate size of the insect, or the family to which it belonged, though its characters are clear enough to show it was *Neuropterous*, and to distinguish it with certainty from the other specimens.

The last specimen, *H. fossilis*, consists of the greater portion of the upper wing of an insect, which Mr. Scudder believes to be the representative of another new family of *Neuroptera*, "synthetic in nature, combining features of the *Odonata* and *Sialina*;" and he

¹ See plate xvii., "Geol. Mag.," Vol. iv., p. 390.

² "Geol. Mag.," Vol. iv., p. 387, 1867; and "Acadian Geology," pp. 524-525, *antea cit.*

³ Mr. Scudder observes of this specimen—"The intercalary nervules which in *Ephemerina* generally originate independently, arise here from a bent cross-vein much as in *Odonata*." "Geol. Mag.," Vol. v., p. 175, 1868.

adds that though it is in a mutilated condition the extent and character of every principal nervure can be determined.

The most noticeable peculiarity of this specimen appears to be a heavy cross vein near the base of the wing—between the principal middle nervures—and from which cross vein new prominent veins take their rise.

Although these Devonian insects are the oldest specimens yet discovered, the families to which they belonged had doubtless existed for ages; and it must not be assumed that even their family types necessarily, or even probably, represented the earliest forms of insect life. In all other classes of the Animal Kingdom, with whose fossil remains we are acquainted, as well as in the Vegetable Kingdom, the simpler forms precede the more highly organised. There seems no reason for supposing that the *Insecta* formed any exception to this rule, and we may fairly assume that the earliest types of this class were likely to have been larger in size, simpler in form, and less specialized than these remarkable *Neuropteroid* insects of the Upper Devonian period; and that they had probably existed for ages before that epoch, as had representatives of the *Crustacea*, the *Mollusca*, and even the *Vertebrata*.¹

Reasoning from the analogy which one may assume to exist between the *Insecta* and other Classes of the Animal Kingdom in progressive development, it seems highly probable that further researches in earlier Devonian strata, and possibly in rocks of even greater age (Silurian), may bring to light more ancient forms of insect life than any yet discovered.

The appearance of insects on the Earth was probably synchronous with that of land plants,² and as remains of this division of the Vegetable Kingdom have been discovered in rocks belonging to the Upper Silurian³ period, the existence of a land flora, ages before the date at which these Devonian insects lived, is proved. The fact of the existence of land plants⁴ at as early a date as the

¹ The oldest known type of fishes is described by J. W. Salter, F.G.S. in the "Annals and Mag. of Nat. Hist.," Vol. iv., 1859.

² It is not impossible, however, that insects may have appeared before land plants, which were not absolutely necessary to the existence of groups similar in their nature to the *Odonata* and *Ephemerina*, which are essentially carnivorous and aquatic in their early stages.

³ Dana's "Manual of Geology," *antea cit.*, p. 245; and "The Origin of the World," by Dr. Dawson, F.R.S., p. 330, London, 1877.

⁴ "In the Upper Ludlow beds (Silurian Period) occur seed vessels called *Pachytheca* by Hooker, and also fragments of stems supposed to be

close of the Silurian period appears to me to be an additional reason to those previously given for assuming the probability of the first appearance of insects at a much earlier age than that of the Devonian shales at "Fern Ledges."

I have, I believe, now enumerated all the known fossil insects which have been obtained from the Palæozoic rocks of the United Kingdom, and the Continents of Europe and America.

The 122 species which have been named and described are Geographically distributed as follows :—

From the United Kingdom ¹	.	.	5
„ Continent of Europe	.	.	79
„ „ America	.	.	38
Total	.	.	122

The Geological distribution of these fossils is as follows :—

From the Permian	.	.	13
„ Carboniferous	.	.	103
„ Devonian	.	.	6
Total	.	.	122

CONCLUSION.

Having in this and the two² preceding papers called attention to those formations of the Post Tertiary, Tertiary, Secondary, and Primary Periods, from which insects have been obtained, and having enumerated the Orders, Families, Genera, and, in many cases, the species to which these fossils have been referred, I propose to offer a few suggestions, as to some of the conclusions which may be arrived at, from a consideration of the facts which have been adduced.

those of *Lycopods* (ground pines). In Germany, at Lobenstein, and at Hostin in Bohemia, *Lycopods* of the *Lepidodendron* family occur. . . . Besides these flowerless species (Cryptogams), others of genera of the pine tribe—the lowest division of flowering plants (Phenogams)—are supposed by Dawson to have existed, and he has referred pieces of carbonised wood from the Upper Ludlow beds to the genus *Prototaxites*" (*πρωτος* first, and *taxis* yew tree). Dana's "Manual of Geology," *antea cit.*, p. 245.

¹ There are, I believe, several species in the collections of the Rev. P. B. Brodie and others which have not yet been described.

² See "Proc. Geol. Assoc.," Vol. v. (No. 6), pp. 282, 343, April 1878; and Vol. vi. (No. 3), pp., 116-150, July 1879.

Let us consider (firstly) what information is afforded by Palæontology on the questions of the origin and progressive development of insects; the order of the apparition of the various groups on the Geological horizon; the antiquity of many of their existing genera; and (secondly) what inferences may be drawn as to the land and fresh water conditions of the Earth, of its climate and vegetation in any former Period, and of the contemporaneous existence of other Classes of the Animal Kingdom from a study of the fossil insects of such Period.

Before proceeding to show what evidence has as yet been furnished by Palæontology, in support of the opinions of many Biologists, as to the evolution or gradual progression of the existing Orders of Insects from some primitive type, it will be necessary to refer briefly, to the writings on this subject of Prof. Haeckel, Dr. Fritz Müller, and Sir John Lubbock.

Prof. Haeckel and many other Biologists are of opinion that the *Crustacea*, *Myriopoda*, *Arachnida*, and *Insecta*, must have had a common ancestor, from which the *Crustacea* first, and through it, the other Classes of the *Arthropoda* are descended.

Dr. Fritz Müller¹ is of opinion that the water-inhabiting and water-breathing *Crustacea*, must be regarded as the original stem, from which the other terrestrial Classes of the *Arthropoda*, with their tracheal respiration, have branched off.

Sir John Lubbock,² writing on the origin and metamorphoses of Insects, observes—"there are good grounds for considering "that the various types of insects are descended from ancestors "more or less resembling the genus *Campodea*,³ with a body divided "into head, thorax, and abdomen; the head provided with mouth "parts, eyes and one pair of antennæ; the thorax with three pairs of "legs; and the abdomen, in all probability, with caudal appendages. "If these views are correct the genus *Campodea* must be regarded as "a form of remarkable interest since it is the living representative of "a primæval type from which not only the *Collembola* and *Thysanura*, "but the other great Orders of insects have derived their origin."

I have felt great reluctance in giving garbled extracts from the works of these eminent authorities, and venturing to allude to their opinions in so cursory a manner; but as some excuse for doing so I

¹ "Facts for Darwin" (translated from the German of Dr. Fritz Müller, by W. S. Dallas), Chap. xi., p. 120, 1876.

² "On the Origin and Metamorphoses of Insects," by Sir John Lubbock, Bart., M.P., F.R.S., Ch. v., p. 92, 1874.

³ An existing genus belonging to the order *Thysanura*.

would observe that it is not within the scope of this paper to discuss the questions of the probable origin and progressive development of insects from Biological data, but merely to call attention to such facts, bearing on the subject, as have been obtained by the researches of the Geologist and Palæontologist; which facts would, however, be scarcely intelligible in their application, without at least an allusion to some of the opinions, before quoted, on these questions.

It must be admitted that, up to the present, we have no record of the discovery in any rocks—even in the most ancient—of any forms of insects which are, *at first sight*, connecting links between existing types and simpler organisms. On this point Sir John Lubbock observes,¹ that “the earliest known *Neuroptera* and “*Orthoptera*, though in some respects less specialized than existing “forms, are as truly and as well characterized insects as any now “existing; nor are we acquainted with any earlier forms which in “any way tend to bridge over the gap between them and lower “groups, though, as we shall see, there are types² yet existing which “throw much light on the subject.”

Even apart from the opinions of the distinguished Biologists before quoted, it would be unreasonable to suppose that the oldest known *Neuroptera* and *Orthoptera*—even though many of them are less specialized than existing forms—represent the earliest types of the Class to which they belong; and we may confidently expect that with the progress of Geological research in the Devonian, and very possibly in the Silurian³ formations, traces of the former existence of winged insects, simpler in form, and even more generalized in structure than any yet discovered, may be brought to light.

Making due allowance for the comparative shortness and incompleteness⁴ of the Geological record, the opinions of Biologists on

¹ “On the Origin and Metamorphoses of Insects,” Ch. v., p. 86, *antea cit.*

² i.e. *Campodea*, referred to on the previous page.

³ Remains of land plants have been discovered in rocks of Lower Silurian age.

⁴ Mr. Darwin's remarks on this point are especially apt—“I look at the geological record as a history of the world imperfectly kept, and written in a changing dialect; of this history we possess the last volume alone, relating only to two or three countries. Of this volume only here and there a short chapter has been preserved; and of each page only here and there a few lines. Each word of the slowly changing language more or less different in the successive chapters, may represent the forms of life which are entombed in our consecutive formations, and which falsely appears to us to have been abruptly introduced.” “The Origin of Species,” by Charles Darwin, F.R.S., 6th edit., p. 289.

the subject of the progressive development of the various Orders of insects, seem to be borne out by the results of such Palæontological researches as have yet been made; and we find that the relative subordination of the existing groups is pretty much in accordance with the order of their Geological succession, the simpler forms preceding the more highly organized. Some of the oldest known insects were, as we have seen, much less specialized than those of the present day, and many of them combined peculiarities of structure now characteristic of separate Orders, such as combinations of characters of *Neuroptera* and *Orthoptera*, of *Neuroptera* and *Hemiptera*, or of *Neuroptera* proper and *Pseudo-Neuroptera*.

These synthetic types, however, were associated with representatives of the most recent forms, and even some of the Devonian Insects—the most ancient known—are, according to Mr. Scudder,¹ to be “referred with very little question not only to the *Neuroptera*, “but even to a particular family of *Neuroptera* now existing—the “May flies. Indeed the presence, at the apparition of a given “group, of modern types side by side with those which elude our “classification of existing forms is one of the peculiar problems of “Palæontology.”

Notwithstanding the occurrence of recent types in the most ancient rocks, the rule that the simpler forms precede the more highly organized, holds good in the main, the oldest *Neuroptera* being represented, almost invariably, by species with incomplete metamorphoses, and the oldest *Orthoptera* including—with the exception of a few *Phasmidæ*, and *Gryllidæ*—hardly any species, except *Blattidæ*, which are more numerous than all the other Palæozoic Insects.

The great rarity of the remains of the *Hemiptera* and *Coleoptera* in the Palæozoic rocks prevents us from ascertaining whether they, like the *Neuroptera* and *Orthoptera*, were chiefly represented at this early period, by their lowest² families.

The scarcity of representatives of these two Orders in Palæozoic rocks can, I think, only be explained on the hypothesis that they

¹ “Mem. Bost. Soc. Nat. Hist.,” Vol. iii., pt. 1, No. 2, 1879.

² Since writing this I have read Mr. Scudder's remarks on the Palæozoic *Hemiptera*, which are as follows:—“We may glean still another fact from the scanty data the rocks afford us concerning the early types of Insects. All the *Hemiptera* of the Palæozoic rocks belong to the *Homopterous* division of this sub-Order, indicating what is generally conceded, that this division is lower than the *Heteroptera*, which first appeared in the Jura.” “Mem. Bost. Soc. Nat. Hist.,” Vol. iii., pt. 1, No. 2, *antea cit.*

made their appearance much later than the *Neuroptera* and *Orthoptera*; had they been fully developed at as early a period as the two Orders last named, their remains would certainly have been preserved at least as commonly as remains of those Orders. This is especially true of the *Coleoptera*, which, from the hardness of their elytra, are capable of preservation under much less favourable conditions than is requisite for the preservation of insects of most orders; and in the rocks of the Secondary and Tertiary Periods, fossils of this Order of Insects are, as a rule, far more abundant than those of any other Order of Insects.

As we have seen, only two species of *Coleoptera* are known from the Palæozoic rocks, and only three from the Trias; but from the Rhoetics several are recorded, and from the Lias great numbers have been obtained; and from this remote period to the present time the *Coleoptera* appears to have been a dominant Order, though, as previously observed, representatives of this class have, from their nature, doubtless been preserved in much greater numbers than insects of most Orders, and may thus appear to have been comparatively more abundant than they really were.

Returning to the *Hemiptera*—it will be remembered that only three species of this Order are recorded from the Carboniferous rocks, and two from the Permian. No species of this Order have yet been discovered in the Trias, but a few are recorded from the English Lias, and several from the Lias of Schambelen.

One or two supposed species of *Diptera*¹ are recorded from the English Lias, but no remains of this Order are known from any Continental formations older than the Solenhofen slate. Both this Order and the *Hymenoptera* appear to be sparingly represented in the Purbecks; but it is not until we reach the formations of the Tertiary age that we find either of them generally distributed or abundantly represented. As Prof. Heer observes—the date of the appearance of these Orders must have depended upon the state of development of the vegetable kingdom, and insects which resort to flowers for their nourishment, could not have existed prior to the period at which the dicotyledonous plants attained a high stage of perfection.

The most modern Order is apparently the *Lepidoptera*, no remains of which are recorded from any strata older than the Stonesfield

¹ Of one of them Prof. Westwood observes—"Seems like the body of a Tipulideous insect." Of another fragment he says, "May possibly be *Dipterous* allied to *Asilus*." Brodie's "Fossil Insects," p. 128.

slate. From this formation, as I have already noticed in my second¹ paper, remains of two *Lepidopterous* (?) insects have been obtained, one of which has been described and figured by Mr. Butler in his "*Lepidoptera Exotica*" as *Paleontina Oolitica*. The question of whether or not this fossil should be referred to the *Lepidoptera*, or to the *Hemiptera* (*Homoptera*), having been discussed at some length in the paper last mentioned, I shall not further allude to it.

With the exceptions of *Paleontina Oolitica*, of two *Lepidopterous*² insects from the Solenhofen Slate, and the two very³ doubtful fragments from the Purbecks, we have no record of the discovery of any well authenticated fossil insects of this Order from older strata than the upper division of the Lower Tertiaries. From formations of this period about twenty-six species of *Lepidoptera* (exclusive of those found in Amber), have been recorded, namely, four from strata of Upper Miocene age, eight from the Middle Miocene, four from the Lower Miocene, and ten (five *Rhopalocera*) from the Upper Eocene. Of these twenty-six species of *Lepidoptera*, ten have been referred to the *Rhopalocera* (or Butterflies), and the remaining sixteen to the *Heterocera* (or Moths).

Of the ten species of butterflies, five have, as I remarked in my first paper, been obtained from formations of the Upper Eocene period, but none have been recorded from older strata of the Tertiary Age.

From the evidence at present obtained by Palæontology, it appears that the *Neuroptera* is the oldest of the existing Orders; that it was followed by the *Orthoptera*, and that these two Orders included almost all⁴ the insects of the Primary or Palæozoic period, towards the close of which the *Hemiptera* and *Coleoptera* began to appear; that comparatively early in the Secondary or Mesozoic Period, the two last named Orders became abundant and widely distributed, and somewhat later were followed by the *Diptera*, and some families of the *Hymenoptera*; and, further, that towards the close of this period other families of the *Hymen-*

¹ See "Proc. Geol. Assoc.," Vol. vi., No. 3; pp., 126 and 127. July, 1879.

² *Sphinx Snelleni* and *Pseudosirex Darwini*.

³ *Cyllonianum Boisduvalianum* and *C. Hewitsonianum*.

⁴ It must, of course, be understood that those ancient types, which, from their combination of the characters of two or more orders or families of insects, have been placed by Dr. Goldenberg in the extinct order (*Palaodictyoptera*) before referred to, are excepted from this generalization.

optera—including the Bees—appeared, and were accompanied, or immediately followed, by the *Lepidoptera*, which last Order, however, does not appear to have been thoroughly established much before the close of the Eocene Division of the Tertiary Period.

In attempting to arrive at any conclusion as to the origin and evolution of Insects, and the order of their Geological succession, from a consideration of the facts derived from Palæontology, the shortness and incompleteness of the Geological record must always be borne in mind, and, as Mr. Darwin¹ remarks, “The crust of the earth, with its embedded remains, must not be looked at as a well filled Museum, but as a poor collection made at hazard, and at rare intervals.”

The force of these observations is especially felt in the particular branch of Palæontology which is the subject of these papers. Although, as we have seen, fossil insects have in certain strata, and in a few widely scattered localities, been obtained in considerable numbers, they appear to be, as a rule, extremely rare; and consequently afford but few data on which to base satisfactory generalizations as to their probable origin, order of succession, and geographical distribution in former ages.

The course of progression through which insects are considered by many Biologists to have attained to their present condition, and the primary relations of the various Orders, have been fully discussed by Sir John Lubbock,² Mr. Darwin,³ Professor Haeckel,⁴ Dr. Fritz Müller,⁵ Dr. Packard,⁶ Mr. Scudder,⁷ and others.

The great antiquity of many of the existing genera of insects, as compared with that of the genera of the Vertebrates, and the very small amount of change⁸ which has taken place in many of

¹ “The Origin of Species,” Ch. xiv., p. 487 (1859).

² “On the Origin and Metamorphoses of Insects,” *antea cit.*

³ “The Origin of Species,” *Antea cit.*

⁴ See “The History of Creation” (an English translation of “*Natürliche Schöpfungsgeschichte*”) by Dr. Ernst Haeckel, 1874; the translation revised by Prof. E. Ray Lankester, 1876.

⁵ “Facts and Arguments for Darwin” (translated from the German, by W. S. Dallas, 1869).

⁶ “Embryological Studies on Hexapodous Insects,” Mem. Peabody Academy of Science, Vol. v., pt. 1, No. 3. “On Synthetic Types in Insects.” Bost. Jourl. Nat. Hist., Vol. vii, 591-2; and “Guide to the Study of Insects,” 1869.

⁷ “The Early Types of Insects.” Mem. Bost. Soc. Nat. Hist., Vol. iii., pt. 1, No. 2, 1879.

⁸ “The general type of wing structure in insects has remained unaltered from the earliest times.” See the paper last cited, p. 21.

them during the Geological record, is very remarkable. The truth of this must be apparent to any one who compares a list of the fossil insects of any Period with a list of the fossils of almost any other Class of the Animal Kingdom, which existed during the same Period. If we take any Order of insects—say the *Coleoptera*—and enquire what families of that Order were represented in the “Purbecks,” we shall find *Buprestidæ*, *Carabidæ*, *Curculionidæ*, *Chrysomelidæ*, *Elateridæ*, *Cantharidæ*, *Tenebrionidæ*, &c. Now all these are existing families, represented at the present day by a great number of species. In what other division of the Animal Kingdom—at any rate amongst the *Vertebrata*—should we find so many families which existed during any part of the Jurassic Period represented at the present day?

Compare the fossils of the English Lias with the existing Orders of the Animal Kingdom. It will be seen¹ that the insect remains of this period have been referred to species distributed amongst the *Carabidæ*, *Telephoridæ*, *Elateridæ*, *Curculionidæ*, *Chrysomelidæ*, *Blattidæ*, and *Gryllidæ*, all of which families are represented at the present day; but, with regard to the *Vertebrata*, where are the representatives at the present day of the Saurians, the flying lizards, and other gigantic reptiles of the Lias? “When we consider,” says Mr. Alfred Russell Wallace,² “that almost the only *Vertebrata* of this period (*i.e.*, the Lias), were huge Saurian reptiles like the *Ichthyosaurus*, *Plesiosaurus*, and *Dinosaurus*, with the flying *Pterodactyles*, and that the great mass of our existing genera, and even families of fish and reptiles, had almost certainly not come into existence, we see at once that the types of insect form are proportionately far more ancient. At this remote epoch we find the chief family types (the genera of the time of Linnaeus) perfectly differentiated and recognizable.”

I will now endeavour to suggest a few of the most important conclusions bearing upon the land and fresh-water conditions of the Earth in former ages, which may be arrived at from a study of fossil insects.

From the fact that some insects are aquatic, and some terrestrial, and that some are carnivorous, some herbivorous and some pre-

¹ See list of species at the end of the 2nd paper. “Proc. Geol. Assoc., Vol. vi., No. 3, July, 1879.

² “The Geographical Distribution of Animals,” Vol. i., p. 167, 1876.

daceous in their habits, it is evident that the prevalence of the remains of any group or family of animals of this Class, in a fossil state, furnishes an important clue to a knowledge of the land and fresh-water conditions of the Earth, and of its climate and vegetation during the period of their existence; and Sir Charles Lyell¹ has remarked "that if this Class of the Invertebrata were "not so rare and local, they might be more useful than even the "plants and shells in settling chronological points in geology."

Where we find aquatic insects fossilized in large numbers in any strata, we necessarily infer the presence of rivers or fresh-water lakes; and the discovery of the remains of numbers of herbivorous insects in any formation certainly implies the former prevalence of a more or less luxuriant vegetation.

Fossil insects also furnish some evidence as to the contemporaneous existence of other Classes of the Animal Kingdom; for instance—the discovery in the Swiss Lias of the remains of coprophagous beetles, whose representatives of the present day are found in the dung of cattle, leads to the inference of the contemporaneous existence of some species of Mammalia, even although no traces of them have been detected in that formation; and the Rev. P. B. Brodie observes that, "the presence of insects in "any formation shows that there must have been animals which "preyed upon them, remains of which have been discovered in the "Oolite (including therein the Purbecks), wherein we have insectivorous mammals."

Finally, I would observe that the conclusions arrived at by Prof. Heer,² from a study of the fossil flora of Europe, as to the various changes of climate which the Continent has undergone in past ages, have been, to a great extent, confirmed by his subsequent examination of the fossil insects of Europe, and a comparison of their families, genera, and species, with those of the existing insect fauna and their geographical distribution.

¹ "Elements of Geology," 6th edit., p. 255.

² "Untersuchungen ueber das Klima und die Vegetations Verhältnisse des Tertiärlandes." Winterthur, 1860. See also the French translation, by Dr. Gaudin, "Recherches sur le Climat et la Végétation du Pays Tertiaire." Paris, 1861.

A LIST OF INSECT REMAINS DISCOVERED IN THE FORMATIONS OF THE PALÆOZOIC PERIOD.

EUROPE.

GREAT BRITAIN.

CARBONIFEROUS.

From the Ironstone of Coalbrook Dale, Shropshire.

ORTHOPTERA.

Gryllacris (*Corydalis*) *Brongniarti*.

COLEOPTERA

Curculioides Ansticii.

From the Coal Measures on the north bank of the Wear, opposite Claxheugh, near Sunderland.

ORTHOPTERA.

Phasmidæ? (supposed species of).

Blattidium mantidioides ¹

From the Scottish Coal-fields in the neighbourhood of Glasgow.

ORTHOPTERA.

Lithomantis carbonarius.

CONTINENTAL EUROPE.

PERMIAN, OR DYAS.

From Schwarzenbach, Birkenfeld, Cassel.

PALEODICTYOPTERA.

Engereon Böckingi.

HEMIPTERA.

Fulgorina (*Fulgora*) *Ebersi*.

From Stockheim, Bavaria.

PALEODICTYOPTERA.

Ephemerites Rückerti.

ORTHOPTERA.

Blattina Rückerti.²

From Weissig, Saxony.

ORTHOPTERA.

Blattina Weissigensis.³ *Blattina anthracophila* (*flabellata*).³

„ *porrecta*.⁴ „ *carbonaria*.³

„ *didyma* (*sopita*). „ *Mahri*.

¹ Referred by Scudder to the genus *Etolblattina*.

² „ „ „ *Anthracoblattina*.

³ „ „ „ *Etolblattina*.

⁴ „ „ „ *Anthracoblattina*.

From Lebach, near Saarbrück in the Rhenish Provinces of Prussia.

ORTHOPTERA.

Blattina lebachensis.¹

„ *gracilis*.²

HEMIPTERA.

Fulgorina (Fulgora) lebachensis.

CARBONIFEROUS.

From the neighbourhood of Saarbrück, in the Rhenish Provinces of Prussia.

PALÆODICTYOPTERA.

Dictyoneura libelluloides.

Dictyoneura elongata.

„ *anthracophila*.

„ *Schmitzii*.

„ *formosa*.

„ *obsoleta*.

„ *Decheni*.

„ *Humboldtiana*.

„ *elegans*.

NEUROPTERA.

Termes Heeri.

Termes laxa.

„ *affinis*.

Termitidium amissum.

„ *Hageni*.

„ *rugosum*.

„ *Buchi*.

ORTHOPTERA.

Gryllacris lithanthraca.

Blattina scaberata.⁵

Acridites formosus.

„ *Wemmetsweileriensis*.⁶

„ *carbonatus*.

„ *Remigii*.⁷

Blattina primæva.³

„ *weissiana*.⁸

„ *labachensis*.³

„ *Tischbeini*.

„ *insignis*.³

„ *venosa*.

„ *winteriana*.⁴

Polyzosterites granosus.

„ *intermedia*.⁵

HEMIPTERA.

Fulgorina (Fulgora) ebersi.

Fulgorina (Fulgora) klieveri.

COLEOPTERA.

Troxites Germari.

¹ Referred by Scudder to the genus *Hermatoblattina*.

² „ „ „ *Petrablattina*.

³ Referred by Scudder in his recent paper in the "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 3, to the genus *Etoblattina*.

⁴ „ „ „ *Anthracoblattina*.

⁵ „ „ „ *Gerablattina*.

⁶ „ „ „ *Hermatoblattina*.

⁷ „ „ „ *Anthracoblattina*.

⁸ „ „ „ *Gerablattina*.

From Manebach, near Ilmenau, in Saxe Weimar.

ORTHOPTERA.

<i>Blattina didyma</i> . ¹	<i>Blattina Mahri</i> . ²
„ <i>Manebachensis</i> . ¹	„ <i>Fritschii</i> ³
„ <i>Goldenbergi</i> ²	„ <i>latinervis</i> .
„ <i>clathrata</i> . ²	

HEMIPTERA.

Macrophlebium Hollebeni.

From Wettin and Lobejün, Prussian Saxony.

ORTHOPTERA.

<i>Blattina euglyptica</i> . ⁴	<i>Blattina carbonaria</i> . ⁴
„ <i>affinis</i> . ⁴	„ <i>didyma</i> . ⁴
„ <i>flabellata</i> . ⁴	„ <i>rossoma</i> . ⁴
„ <i>anthracophila</i> . ⁴	„ <i>leptophlebica</i> . ⁴
„ <i>Dorhnii</i> . ⁴	„ <i>parvula</i> . ⁴
„ <i>anaglyptica</i> . ⁴	

ORTHOPTERA.

<i>Blattina spectabilis</i> . ⁵	<i>Blattina producta</i> . ⁶
„ <i>Geinitzi</i> . ⁶	„ <i>Germari</i> . ⁶
„ <i>Münsteri</i> . ⁶	„ <i>reticulata</i> . ⁷

From Klein-Opitz, near Dresden, Saxony.

ORTHOPTERA.

Blattina Dresdensis.⁸

From Erbignon, Valais, Switzerland.

ORTHOPTERA.

Blattina helvetica.⁹

From Sars-Longchamps, Mons, Belgium.

PALEODICTYOPTERA.

Omalia macroptera.

NEUROPTERA.

Breyeria Borinensis. *Termes* ? (a supposed species of).

¹ Referred by Scudder in his recent paper in the "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 3, to the genus *Etoblattina*.

²	"	"	"	<i>Gerablattina</i> ,
³	"	"	"	<i>Progonoblattina</i> .
⁴	"	"	"	<i>Etoblattina</i> .
⁵	"	"	"	<i>Anthracoblattina</i> .
⁶	"	"	"	<i>Gerablattina</i> .
⁷	"	"	"	<i>Oryctoblattina</i> .
⁸	"	"	"	<i>Anthracoblattina</i> .
⁹	"	"	"	<i>Progonoblattina</i> .

ORTHOPTERA.

Pachytylopsis Persenairei.

From Commentry, Allier, France.

ORTHOPTERA.

Protophasma Dumasii.

AMERICA.

CARBONIFEROUS.

From the neighbourhood of Sydney, Cape Breton.

PALÆODICTYOPTERA.

Haplophlebium Barnesii.

NEUROPTERA.

Libellula (?) *carbonaria*.

ORTHOPTERA.

Blattina Heeri.¹*Blattina sepulta*.,, *Bretonense*.¹From Mazon Creek, and elsewhere, near Morris, Danville,
and Colchester, Illinois.

PALÆODICTYOPTERA.

Paolia vetusta.

NEUROPTERA.

Miamia Bronsoni.²*Crestotes lapidea*.,, *Danae*.²*Hemeristia occidentalis*.*Megathentomum pustulatum*.*Euephemerites affinis*.*Euephemerites simplex*.*Termes contusus*.,, *gigas*.

ORTHOPTERA.

Mantis? (supposed species of).*Lithomylacris simplex*.*Mylacris anthracophilum*.From Cannelton, Beaver Co., and Pittston, Luzerne Co., Penn-
sylvania.

NEUROPTERA.

Euephemerites primordialis.¹ These two species have been re-described by Mr. Scudder in the paper before mentioned ("Mem. Bost. Soc. Nat. Hist.," Vol. iii.), and referred to the genus *Mylacris*.² Both these species have been referred by Goldenberg to the extinct order *Palæodictyoptera*.

ORTHOPTERA.

Archymylacris parallelum.	Lythomylacris angustum.
Mylacris Pennsylvanicum.	„ pittstonianum,
„ Mansfieldi.	Etoblattina Lesquereuxii.
Necymylacris heros.	Blattina fascigera. ¹
„ lacoanum.	

From Frog Bayou, Arkansas.

ORTHOPTERA.

Blattina venusta.²

From Pictou, Nova Scotia.

ORTHOPTERA.

Mylacris acadicum.

From Tallmadge and Bellaire, Ohio.

ORTHOPTERA.

Archegogryllus priscus. Gerablattina balteata.³

DEVONIAN.

From "Fern Ledges," near Carleton, St. John's, New Brunswick.

NEUROPTERA ⁴ AND PSEUDO-NEUROPTERA.

Xenoneura antiquorum.	Lithentomum Harttii.
Gerephemera simplex,	Dyscritus vetustus.
Platephemera antiqua.	Homothetus fossilis.

¹ Recently referred by Scudder to the genus *Gerablattina*.

² " " " *Etoblattina*.

³ A second specimen of this species is recorded by Scudder from Cassville, Western Virginia.

⁴ These insects have been placed by Dr. Goldenberg in the extinct Order *Palæodictyoptera*; but Mr. Scudder considers Goldenberg to have "gone too far" in referring them to this Order.